

Zion-Mount Carmel Highway Tunnel
Zion National Park
Springdale vicinity
Washington County
Utah

HAER No. UT-39-A

HAER
UTAH,
27-SPDA.V,
3A-

PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

Historic American Engineering Record
Rocky Mountain Regional Office
National Park Service
Department of the Interior
P.O. Box 25287
Denver, Colorado 80225

HISTORIC AMERICAN ENGINEERING RECORD

Zion-Mount Carmel Tunnel

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Location: Zion National Park
Springdale vicinity, Washington County, Utah

Date of Construction: 1930; Alterations - 1951, 1958

Present Owner: National Park Service
U. S. Department of the Interior

Original Use: Highway Tunnel

Present Use: Highway Tunnel

Significance: The 5,613-foot long, rock-faced Zion-Mount Carmel Tunnel with concrete spines was completed in 1930 and retains structural integrity. It is one of the most spectacular manmade sites at Zion National Park and is the only one of its kind in the Rocky Mountain Region.

Researcher: James Jurale
September 24, 1984

Due to the urging of Utah Parks Company officials, the Federal Bureau of Public Roads and the Utah State Road Commission began studying ways by which the scenic points of interest in southern Utah and northern Arizona could be linked. In June 1923, B. J. Finch, the District Engineer of the USDA Bureau of Public Roads at Ogden, and Howard C. Means, a Utah State Engineer, arrived in Zion National Park. There, they met with John Winder, an East Rim rancher who was a leading authority on the rugged Zion back country. After extensive exploration of the area, the three men concluded that a road up Pine Creek, with a tunnel through the Great arch, was the most logical route to provide access into the park from the east. In 1925, the National Park Service helped conduct a survey of alternative routes, including one up Parunuweap Canyon, but Pine Creek was ultimately selected. Completed in 1930 at a cost of \$503,000, Congressman Louis C. Crampton of Michigan, chairman of the Subcommittee for Appropriations for the National Park Service, sponsored the appropriations that made construction possible.

The Nevada Construction Company of Fallon, Nevada, was the lowest bidder on the contract and, in 1927, began construction on the six galleries that are visible today. Pilot tunnels were drilled and then enlarged with an Erie Air Shovel to a width of 22 feet and a height of 16 feet. Narrow gauge railcars hauled the waste material from the drillings and dumped it into the canyon below through the galleries. In 1951, Gallery #14 was reinforced with concrete after being damaged by a rock slide. A second gallery was partially sealed and that portion of the tunnel near the gallery reinforced with steel and concrete following a rock slide that occurred in 1958.

The tunnel is 5,613 feet in length. The grade within the tunnel is approximately 4 percent, with an elevation increase of 281 feet from the west (5,115 feet) to the east (5,396 feet) end. The west entrance is faced with coursed, rock-faced, ashlar, sandstone outlining the opening with a key-stoned arch. Today, about one-half of the yearly visitors to Zion National Park enter from the east entrance by way of the Zion-Mount Carmel Highway Tunnel. It is no longer possible to stop in the tunnel and view out from the galleries, as Park officials have determined that modern automobiles present a traffic hazard when they attempted to utilize the original narrow parking spaces built there.

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ADDENDUM TO
ZION-MOUNT CARMEL HIGHWAY,
ZION-MOUNT CARMEL HIGHWAY TUNNEL
On Zion-Mount Carmel Highway,
3.6 miles east of North Fork Virgin River
Zion National Park
Springdale vicinity
Washington County
Utah

PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

REDUCED COPIES OF MEASURED DRAWINGS

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This report is an addendum to a 2-page report previously transmitted to the Library of Congress.

Location: Located on Zion National Park's portion of the Zion-Mount Carmel Highway. The west portal is 3.6 miles east of the North Fork Virgin River Bridge, Springdale vicinity, Washington County, Utah.

West Portal UTM: 12/326270/4119950
East Portal UTM: 12/327830/4120040
USGS Quad: Springdale East, UT 1980

Dates of Construction: 1927-1930

Type of Structure: Vehicular tunnel

Use: Vehicular tunnel

Designer/Engineer: U.S. Department of Agriculture, Bureau of Public Roads; U.S. Department of the Interior, National Park Service.

Builder: Nevada Contracting Company, Fallon, Utah.

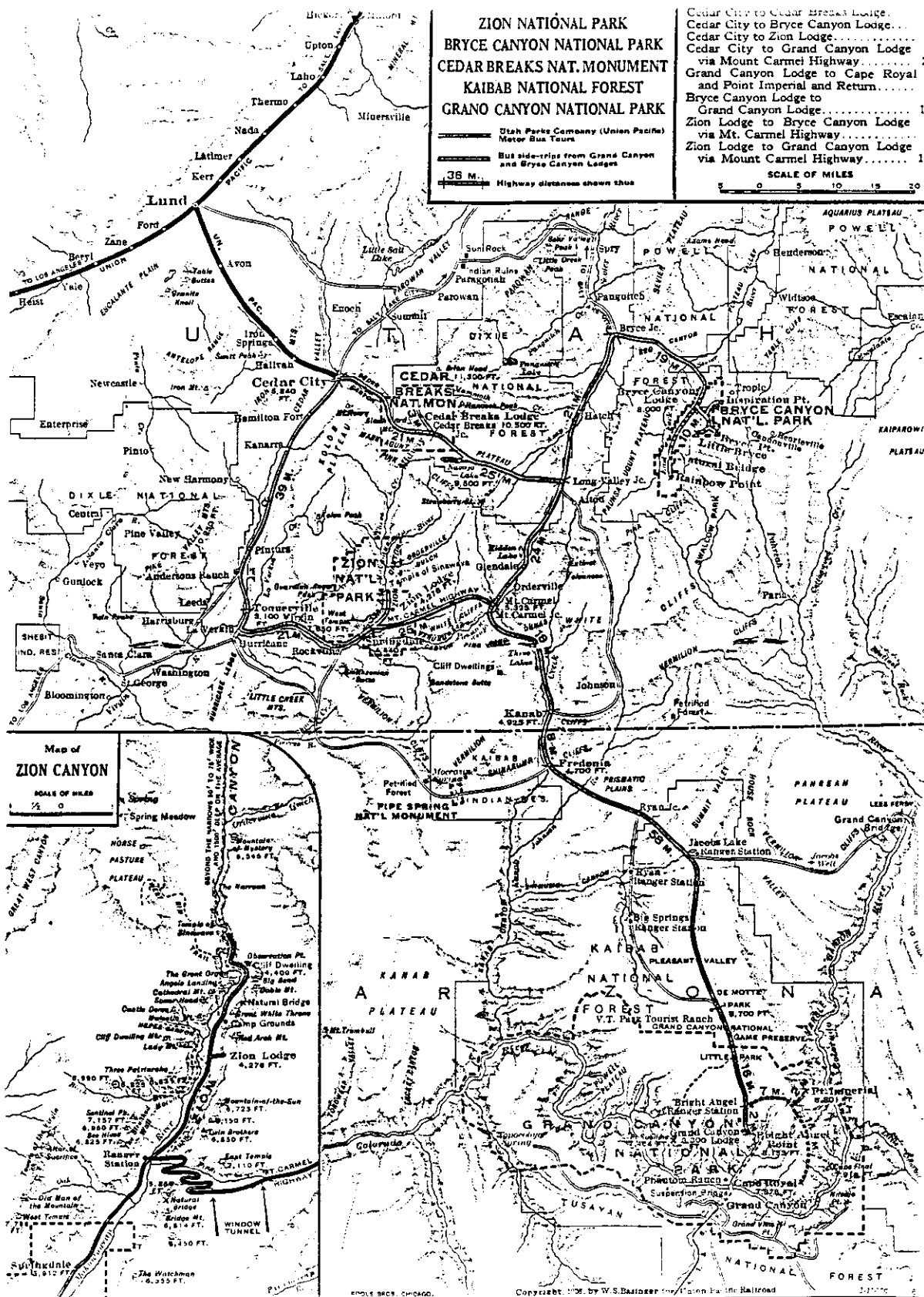
Owner: National Park Service.

Significance: The tunnel is the longest constructed vehicular tunnel in the National Park system (5,613'), and in the western United States at the date of its completion. Aspects of its construction are unique, such as initial boring through side galleries rather than entrance portals. The tunnel is also significant for its association with the Zion-Mount Carmel Highway, the most expensive and one of the most difficult highways constructed by the National Park Service at its completion in 1930.

Project Information: Documentation of the Zion-Mount Carmel Highway Tunnel is part of the Southwestern Roads and Bridges Recording Project, conducted in 1993 under the co-sponsorship of Zion National Park and HABS/HAER.

Michael F. Anderson, HAER Historian, August, 1993.

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INTRODUCTION

The 5,613' Zion-Mount Carmel Highway Tunnel is the major engineering structure along the 25-mile Zion-Mount Carmel Highway, which connects southern Utah's principal north-south transportation arteries: Interstate 15 and Highway 89. Completion of the tunnel in 1930 solved the most vexing problem of building this road, and marked a number of firsts in the history of road building. The tunnel is entirely within Zion National Park, created by act of Congress in November, 1919.

HISTORICAL CONTEXT

Popular needs and demands for better east-west transportation in southwestern Utah lagged fifty years behind the earliest European-American settlement in the region. Mormon colonizers migrating south from Salt Lake City had settled the Virgin River Valley and Zion Canyon by the early 1860s, but for several generations had more pressing concerns than construction of a road to the east. Cattle ranching and subsistence farming in the semiarid high desert region kept the settlers busy close to home, while trade and communication typically led west and north whence the pioneers had come: to the string of towns connecting the western boundary of the Mormon State of Deseret.

By the turn of the twentieth century, local citizens of Rockville and Springdale immediately west of Zion Canyon had satisfied their few needs for access to the high plateau country. John Winder, a settler in the region since the 1880s, had improved an old Southern Paiute Indian trail to the east rim which served cattlemen as well as operators of the Zion cableworks--the astonishing aerial tramway built in 1901 to transport lumber from the rim to Zion Canyon below. The road leading to the base of this trail at the lower cableworks (today's Weeping Rock area) was little more than a set of wagon ruts to be sure, but sufficed for driving cattle between summer and winter ranges and for moving lumber and supplies to and from the lower end of the cable system.

Demands for better roads, not only in the Zion region but everywhere in the United States, awaited the dawn of the automobile age. As the nation awoke to the scenic splendors of the American West and coincidentally fell in love with the automobile, motor enthusiasts lobbied in varied ways for better conduits to the national parks and forests. Motorists and businessmen alert to the possibilities of tourism first raised the cry in southwestern Utah in the 1910s, and it was not long before the State of Utah and the federal government responded

with a decades-long program to improve transportation to and within Zion National Park.

A number of factors combined by 1920 to argue for a road passing through Zion National Park and connecting Highway 91--the "Arrowhead Trail"--25 miles to the west with Highway 89 equidistant to the east. Population and business growth in Kane County east of the park argued for an all-season, all-weather road across the north-south mountain range (the Hurricane Fault region) to the nearest railhead at Cedar City, Utah. Development of local scenic wonders--Zion, Cedar Breaks, Bryce Canyon, and North Rim of the Grand Canyon--and the emergence of a circle tourism route which connected the nascent parks suggested a shorter more scenic route if a road could be built through Zion. These factors, and a growing desire among locals for tourism opportunities, led to the location, survey, and construction of the Zion-Mount Carmel Highway in the years 1923-1930.

HISTORY OF THE STRUCTURE

Location and Survey

The history of the Zion-Mount Carmel Highway is conveyed in a related report (HAER No. UT-39), but the location of that road is inextricably tied to the identification of a suitable means to ascend from Zion Canyon to the plateaus far above. This was the principal problem facing B. J. Finch, District Engineer for the Bureau of Public Roads, and Howard Means, Chief Engineer for the Utah State Road Commission, when they travelled to Zion in 1923 to locate a highway route. These men joined with John Winder to explore the near wilderness east and west of Zion Canyon in the hope of finding a practical ascent. Ultimately, they determined the best route would proceed from the mouth of Pine Creek and ascend to the 100' fall adjacent to the Great Arch of Zion. They considered and rejected the idea of tunneling through the arch and imagined, rather, a half tunnel astride or full tunnel within the face of the Navajo sandstone cliff on the south side of the creek.¹

¹ R. R. Mitchell, Associate Highway Engineer, "Location Report, Zion Park-Mt. Carmel Road: Zion Park Section," 1926, Zion Tunnel and Road Reports File, Park Administrator's vault, Zion National Park (ZNP); Donald T. Garate, "The Zion Tunnel: From Slickrock to Switchback," undated manuscript, Zion Natural History Association (ZNHA) files, ZNP.

Donald Garate's manuscript was edited and published as The Zion

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Two years later, in August, 1925, Finch returned with Associate Highway Engineer R. R. Mitchell for a reconnaissance of the general highway route. In October, 1925, Mitchell returned to Zion Canyon with Senior Highway Draftsman K. B. Campbell and Transitman T. A. Jones for a formal location. Difficulties with the terrain required the men to blast a 100' trail along the side of a cliff to carry the survey above the 100' fall near the great arch, and to transport supplies up to the east rim with an improvised cable system--all in the near vicinity of the proposed tunnel.²

In February 1927, district personnel of the Bureau of Public Roads (BPR) submitted plans, specifications and estimates for the Pine Creek route, and in March began the required topographical work for the tunnel location. They completed contour maps of the cliff face in May, which revealed that the cliff face was much too irregular and unstable to consider an exterior half tunnel, but that a tunnel was possible within the cliff face and would require no more than a 5 percent grade to gain the east rim. The BPR also determined that galleries venting to the outside would be required, and points were chosen at 750, 1452, 2752, 4047, and 4745' east of the west portal--locations providing a concave surface and the greatest amount of available light (later, a gallery would be added 518' from the east portal, thus, Gallery 6 is immediately west of Gallery 1). Engineers would construct the tunnel in a series of tangents between the above points, with curves at the galleries connecting the lines.³ Despite the fact that surveyors could not lay out the tunnel route from above nor even approach the proposed west and east portals due to inaccessible terrain, and worked without USGS topographical maps (first drawn in the early 1930s), the BPR completed specifications and were able to solicit bids by 2 August 1927.

Tunnel: From Slickrock to Switchback (Zion Natural History Association, 1991, Revised edition). The 52-page booklet is excellent for reproductions of historical photographs and road statistics, but lacks construction detail, thus, the author relied on Garate's manuscript rather than the booklet as a principal source.

² Mitchell, "Location Report"; ZNP Superintendent's Annual Report, 1925, Zion Codex, ZNP Library.

³ R. R. Brown, Associate Highway Engineer, "Final Construction Report on East Rim Road Route #1," manuscript, 1931, Zion Tunnel and Road Reports File, Park Administrator's vault, ZNP, 12-13.

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The highway project's first contract called for construction of the Zion-Mount Carmel Highway Tunnel (except for its paving, gunite lining, and tunnel portal) as well as grading, graveling, and minor structures for the road approaching the west portal. The BPR opened bids 31 August 1927, and recommended award to the Nevada Contracting Company of Fallon, Nevada, for the bid price of \$607,058.⁴ The Secretary of the Interior approved the contract on 7 September and planning for the approach road from the park checking station to the west portal (Section 1) and the tunnel itself (Section 2) began on 13 September.⁵

Agreements made to complete the entire 25-mile length of the Zion-Mount Carmel Highway within three years, coupled with National Park Service landscape requirements and the inaccessibility of much of the highway route, necessitated simultaneous construction of Sections 1 and 2 and completion within 325 calendar days. Tunnel construction posed difficulties, since crews had no way to approach the tunnel site until they could complete a pioneer trail or road from above or below. These difficulties accounted for the varied strategies employed in the construction of Sections 1 and 2, which would include a trail from Pine Creek to the base of the cliffs conforming to the line of the proposed road, the opening of multiple galleries in the cliff face and tunneling in both directions from each gallery, driving a pioneer bore followed closely by tunnel enlargement, building a construction camp half way up the talus slope of Section 1, constructing a temporary aerial tram from Pine Creek to the camp, and the employment of other time and landscape saving efficiencies that would have been unnecessary had the company been allowed to start from Pine Creek and move upward.⁶

Construction

Work began 23 October 1927, when Tunnel Superintendent R. N. Scott along with 16 men started the pioneer trail from Station 170 above Pine Creek and carried it past the proposed construction camp site at Station 130 up to the cliffs at the sites of Galleries 6 and 1. Later, men strung a 1-1/8" Tru-lay wire rope trolley 1,000' to gain 700' in elevation to a 40' tower at the top of the slope beneath the base of the cliffs. They

⁴ Brown, "Final Construction Report," 15.

⁵ Ibid., 18.

⁶ Ibid., 19-22.

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used this tram to haul drills, transformers, compressors, 3,000-pound compressor frames and other heavy equipment to the job site. Crews built scaffolding from the base of the cliffs to the exact gallery sites while awaiting the portable compressors. Drilling began on Gallery 1 on 8 November and on Gallery 6 on 14 November. By 19 December, pilot tunnel headings were started between Gallery 6 and 1, and between Gallery 6 and the west portal.⁷

While work progressed on and between Galleries 1 and 6, crews extended the pioneer trail at the base of the cliffs beneath the sites of Galleries 2, 3, and 4; laid a water line and 5" air line alongside the trail; completed scaffolding to the site of Gallery 2; and commenced drilling at that site on 4 December. Others assembled an inclined tramway to reach the site of Gallery 3, some 200' above the trail, and began blasting out this gallery 22 January 1928. As the pioneer trail reached each gallery site, crews extended water and air lines and built scaffolding, tramway, or stope to begin driving into the face of the cliff, then turned in both directions at tunnel line to bore toward the other galleries. Since the site of Gallery 4 could not be reached from the outside, crews dug a 45° stope (access tunnel) from the cliff base to tunnel grade, then turned along the projected tunnel path eastward, and at the computed point blasted the gallery out from the inside. Gallery 5 was also inaccessible from the cliff face, so crews bored east along the tunnel line from Gallery 4, turned at the appropriate point, and blasted this final window through the cliff face. Ring drilling commenced between Gallery 6 and the west portal 18 February 1928, and thereafter moved east, pressing the pilot bore crews but lagging an average of several hundred feet behind for safety reasons.⁸

Pilot and Main Bores

A remarkable engineering aspect of the tunnel project involved the boring of an 8' x 9' pilot tunnel followed by a process of "ring drilling" to achieve the main tunnel dimensions of 16' x 22'. Pilot crews ultimately worked 1,275 consecutive shifts to complete the initial tunnel. As each shift came to work, survey

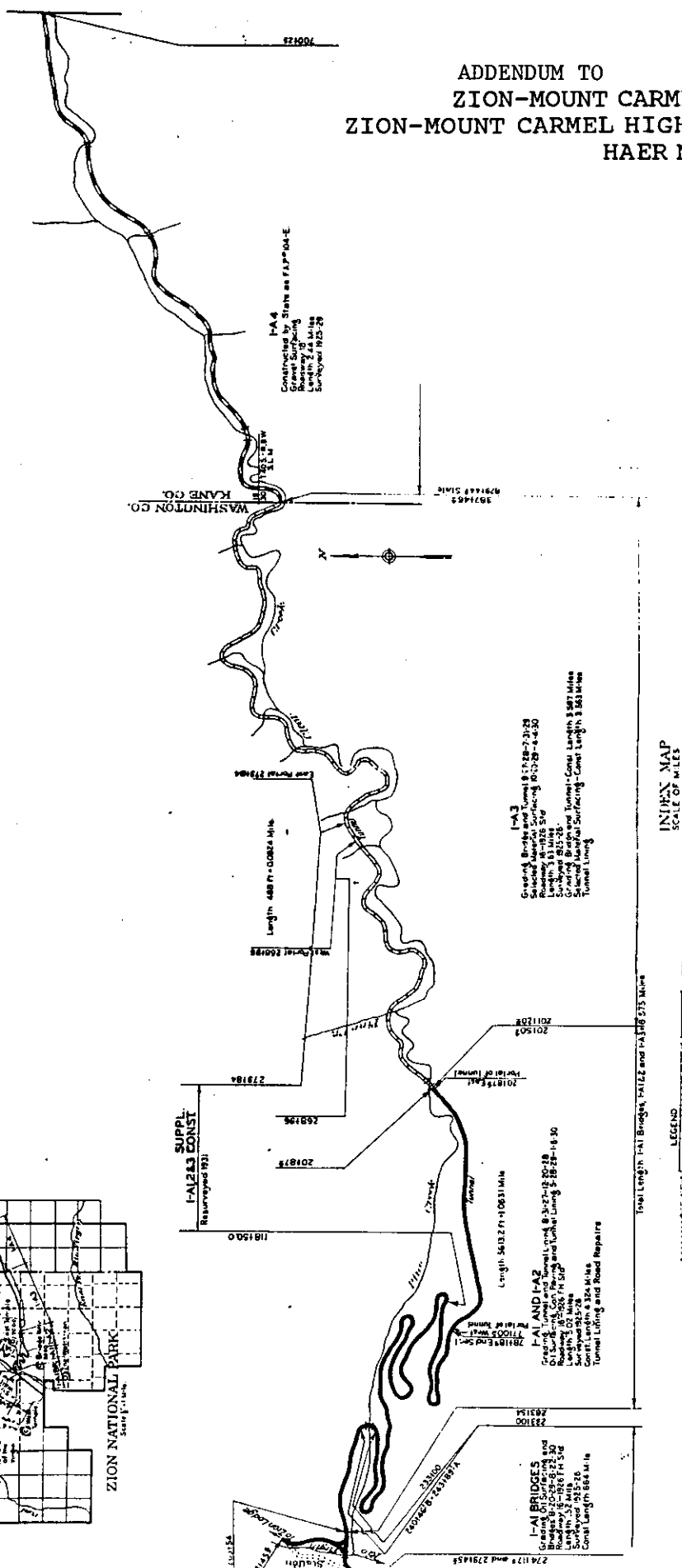
⁷ Ibid., 29-31; Garate, "The Zion Tunnel," 26; O. D. Barnhill, "The new Zion National Park highway opens Utah's 'Dixie Land'," The Explosives Engineer (August 1929): 296-299; "Constructing Zion Park Highway Tunnel," Public Works (February 1929): 78-80.

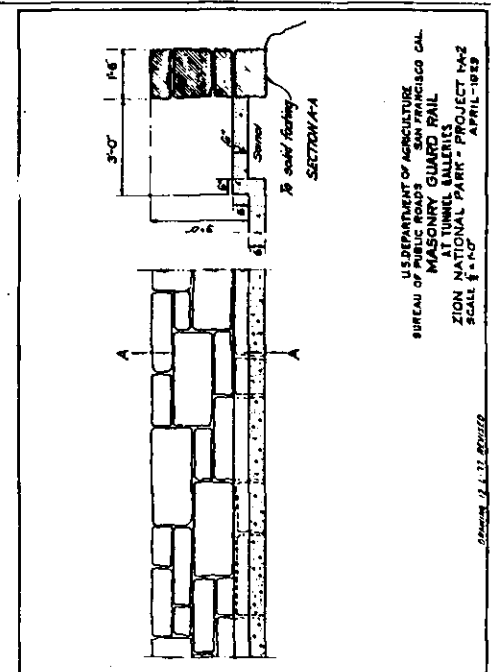
⁸ Brown, "Final Construction Report," 31-34.

The map shows Zion National Park, Utah, with its boundaries and major roads. Key features include the Visitor Center, Scenic Overlook, and the Park's entrance. The map also shows the surrounding area, including the town of Springdale and the state of Missouri. A scale bar indicates distances in miles.

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3	Plan	77+00.0 to 100+50.0
4	Gallery #1	Dist 12-0 to 230 "
5	Gallery #2	Dist 12-0 to 231 "
6	Gallery #3	Dist 12-0 to 232 "
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engineers determined their center line and drift while the men set up the drill framework and began shoveling the rubble left by the last shift into mining cars. Sullivan and Butler mucking machines helped load the cars and a Sullivan compressed-air tugger powered the cars to the nearest gallery where the muck was dumped into Pine Creek Canyon. Other members of the crew installed timber shoring and extended the track into newly blasted tunnel segments. Once the crews had the routine down pat, and barring any unforeseen events, they were expected to move the tunnel face forward an average of 8' per eight-hour shift.⁹

With a set procedure of setup, drill, blast, and muck, the tunnel progressed from each opened gallery. After placing equipment, pilot crews drilled rows of 8' holes in the tunnel face. From the top of the tunnel face these consisted of four back holes, four breast holes, six cut holes, 6 relievers (easers), and finally four lifters at the bottom of the face. Drilling required three to four hours. Next, dynamite was loaded into the holes, two sticks first, followed by a blasting cap and fuse then another six sticks. All fuses were tied to a short fuse, while men and equipment moved back to the nearest gallery and the charge was set. Fuses were timed to detonate one row at a time at two-minute intervals, beginning with the relievers and followed by the breast holes, cutters, top holes, side holes, and finally the lifters which moved the muck away from the tunnel face. The explosions vented at the galleries and reverberated throughout Zion Canyon as electric exhaust fans cleared the shaft of dust and smoke. Each shift then "scaled" loose rubble from the ceiling and walls before returning to camp.¹⁰

Main bore crews began to expand the pilot tunnel to full size on 18 February 1928, at Gallery 6 and moved in the direction of the recently opened west portal. They used the process known as "ring drilling," first employed at the Moffat Railroad tunnel in Colorado. Men setup several self-radiating, reverse feed cylinder, stoping drills along tunnel center line at regular intervals. Each drill was rotated to complete seventeen holes along its "column," or "ring," from the base of one tunnel wall across the ceiling to the base of the other wall. When a full ring was drilled, men moved the equipment forward three feet and started another until they had effected 10-12 rings. They then packed each ring with about fifty pounds of dynamite (20 percent ammonia, 40 percent gelatin) and fired them all at once. The

⁹ Garate, "The Zion Tunnel," 26-27.

¹⁰ Ibid., 27-29; Idem., The Zion Tunnel, diagram, 37.

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crew then completed their shift using half-yard air shovels to load the muck into two-yard trucks, which dumped the debris out the nearest gallery or the west portal. Since ring-drilling progressed at 30'-36' per eight-hour shift while pilot boring moved at only 8' per eight-hour shift, main bore crews proceeded cautiously and at a safe distance behind the pilot crews. Still, they managed to set at least one world record by boring out the main tunnel a distance of 350' in a one-week period.¹¹

On 16 September 1928, pilot crews holed through at the east portal and on 19 October ring drilling crews completed the tunnel's main bore. For the next two months, men trimmed and shot tight places in the main bore. The contractor completed the tunnel project, except for paving and minor cleanup, by mid-December and the BPR recommended acceptance of the contract work 20 December 1928.¹²

Difficulties Encountered

The construction timetable and standard methods of drilling the tunnel and associated galleries are easy to relate, but the task required more ingenuity and adjustments than is suggested. From the beginning, locating the tunnel proved a challenge. Since surveyors found it impossible to run a line over the top of the mountain, they were forced to project one from base lines along the pioneer trail near the base of the cliffs. They located hubs set at the proposed gallery sites by triangulation from base lines on the opposite side of Pine Creek Canyon. They plotted tunnel curves with a minimum radius of 225', and were constrained by the requirement of allowing at least 21' from tunnel centerline to the face of the cliff. Prior to construction, the BPR regional office's review of the tunnel plans revealed a need for a sixth gallery near the west portal, just one of the many adjustments required as the project was underway.¹³

Crews drifting the pilot tunnel east from Gallery 1 encountered unstable ("heavy") ground and designers had to shift the tangent between Galleries 1 and 2 deeper into the cliff. This in turn required a compound curve between Galleries 6 and 1. Unstable ground also demanded adjustments to the length and locations of

¹¹ Garate, "The Zion Tunnel," 34-35; Idem., The Zion Tunnel, diagram, 37; Barnhill, "The New National Park Highway."

¹² Brown, "Final Construction Report," 33-34.

¹³ Ibid., 38-39.

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the two galleries. A similar instance of unstable ground at the site of Gallery 3 required the tunnel to be moved 37' deeper into the cliff near this location. Drilling of the pilot bore revealed that 580 linear feet of tunnel would have to be lined, at stations 76+91 - 75+62, 75+32 - 74+94, 67+80 - 64+54, 63+10 - 62+88, and 47+03 - 46+38. At these sections, pilot tunnel on grade was discontinued and a top heading on spring line grade was driven, with lining placed between spring line and the tunnel roof. The bench below the top heading was later breast-drilled and upright posts to support the lining placed under the wall plates. Lining timbers measured 8" x 8" for 64 linear feet (replaced in 1932-33 with 12" x 12" timbers) and 12" x 12" for the remaining 516 linear feet. This work was completed in May 1928. Despite Highway Engineer R. A. Brown's assessment that "no particular problems were encountered in driving the tunnel" and "the formation through which it was driven was solid sandstone," these and other problems with the rock along the tunnel's path promised later difficulties with tunnel stability.¹⁴

The locations of Galleries 4 and 5 far above the talus slope at the base of the cliff required added work and some engineering ingenuity to complete these structures. As mentioned previously, crews opened Gallery 4 from the inside by blasting a stope from the base of the cliff to the approximate tunnel grade. The line of the stope was calculated from a hub on the talus slope, figuring latitude, departure, and elevation to an arbitrary point on the tunnel grade. When this (theoretical) point was reached, the tunnel drift was driven to the calculated point at the proposed curve of the gallery site, thence out to the face of the cliff. Gallery 5 presented less a challenge as men "simply" continued the tunnel from Gallery 4 along the designed line, then turned to blast through to the face of the cliff at the proposed site. When the final explosion revealed the light of day at the east portal on 16 September 1928, the actual tangent deviated from the calculated line by only a few inches.¹⁵

¹⁴ F. Leroy Davis, Junior Highway Engineer, "Final Construction Report on East Rim Road Supplemental Construction, 1932-1933," manuscript, 1935, Zion Tunnel and Road Reports File, park administrator's vault, ZNP, 2; Brown, "Final Construction Report," 34-36, 40-42.

¹⁵ Ibid., 42-43.

Equipment and Work Force

Considering the difficult topography and the enormity of the task to create a curving tunnel more than a mile in length within a set distance of a cliff face, engineers and miners made few errors in calculation and no errors which could not be corrected with adjustments to location or alignment. The entire section force completed all but minor cleanup tasks in 273 calendar days, well within the allotted 325 calendar days.¹⁶ The speed and accuracy achieved is a tribute to the planning, location, and design work of the Bureau of Public Roads and Nevada Contracting Company, but also a function of new road-building equipment and technologies of the 1920s. Men who built roads in this region thirty years earlier brought picks, axes, shovels, and horse-drawn wagons to the task, and hardly envisioned vehicular tunnels. The contractor brought the following equipment to the Zion-Mount Carmel Highway Tunnel project:¹⁷

- 6 jackhammers
- 12 liners and stopers
- 2 150 HP motors
- 2 Sullivan stationary compressors, 850 cu. ft. capacity each
- 2 portable compressors
- 1 tunnel type, Erie Air Shovel, 1/2 yard capacity
- 5 Mack trucks, 3 to 5 yards each
- 1 Butler Mucking Machine
- 1 Sullivan Mucking Machine
- 7 mine cars
- 4 Sullivan Tugger Hoists
- 1 automatic drill sharpener, oil burner
- 4 Worthington steam pumps
- Miscellaneous track, pipe, electrical equipment, small tools

The contractor also employed some 200 men and pursued an aggressive work schedule, fielding three 8-hour shifts each day between 1 December 1927, and 20 August 1928, to complete the pilot and main bores. Pilot tunnel drift averaged from 9.7 to 19.6' per day, depending on location and difficulties with rock and equipment. Progress averaged a brisker 13.5 to 19.6' per day when the contractor paid a bonus. Salaries for unskilled laborers averaged about \$2.00 per day, while skilled workers made from \$5.50 per 8-hour shift for compressormen to \$12.00 per 8-

¹⁶ Ibid., 38.

¹⁷ Ibid., 36.

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hour shift for shovel runners. For his own efforts, the general contractor made \$29,680.75 or 8+ percent profit, receiving payments of \$387,868.73 for work on the tunnel and expending \$358,178.98.¹⁸

The Nevada Contracting Company also won the contract to pave and curb the roadway within the tunnel, install limited gunite lining, and construct the masonry west portal (along with surfacing of Section 1 roadway) for the bid price of \$156,469. Some of this work resulted from studies in late 1929 of the sandstone within the recently completed tunnel which revealed a need for concrete lining at Galleries 6 and 2, an additional 400 linear feet of 12" x 12" timber lining, and 1" gunite lining on the tunnel roof--spring line to spring line--where timber lining did not exist. Contractor and subcontractors completed the timber lining 10 August 1929; reinforced concrete lining at Galleries 6 and 2, on 26 October; the masonry west portal, 29 November; guniting, 23 November; concrete surfacing of roadway within the tunnel, 12 December; and curbing, 6 January 1930. Nevada Contracting Company sublet the gunite work to the Cement Gun Construction Company of San Francisco; production of the aggregate for the concrete lining, gunite, paving, and curbs to the Cedar Construction Company of Cedar City, Utah; and construction of the west portal to the firm of Shea and Shea. All told, the contractor lost \$31,000 on payments from the Bureau of Public Roads of approximately \$170,000 for this portion of the project.¹⁹

Major Repairs and Alterations, 1930- 1937

The Bureau of Public Roads undertook some maintenance and supplemental construction within the tunnel and other sections of the highway project between February and August 1930, with force account labor. The entire project was completed and accepted by the National Park Service in August 1930.²⁰

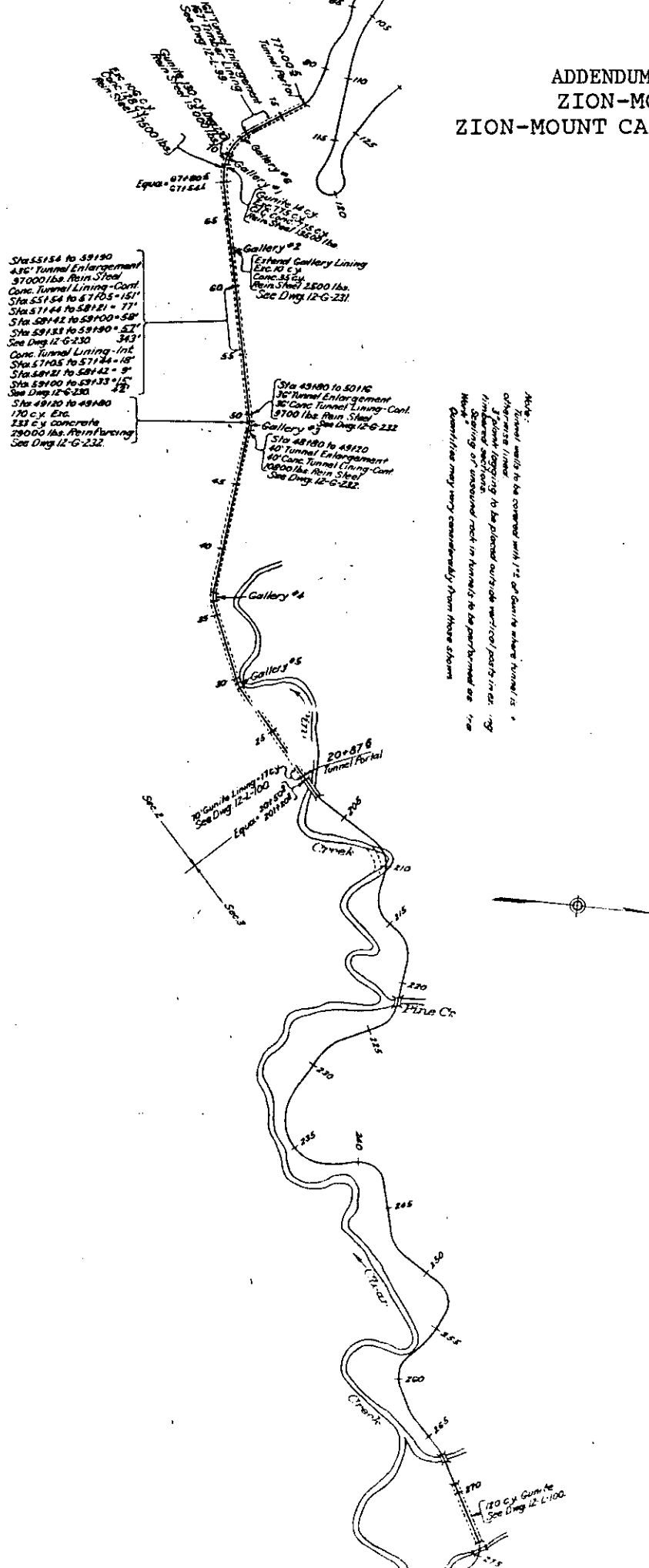
Soon after completion of the Zion-Mount Carmel Highway Tunnel, park administrators noticed cracks in the sandstone and along gunite surfaces and requested an inspection. The federal government assigned Dr. Herbert E. Gregory, geologist with the

¹⁸ Ibid., 34, 36-38.

¹⁹ Ibid., 54-56; Davis, "Final Construction Report Supplemental," 2; Garate, "The Zion Tunnel," 46.

²⁰ Brown, "Final Construction Report," 63.

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U.S. Geological Service, to investigate the structure in August 1931. Dr. Gregory found several zones of structural weakness, which prompted the BPR to request a study by the U.S. Bureau of Mines. Dr. W. R. Crane, Senior Mining Engineer, and R. A. Brown completed another study in November 1931, which suggested possible imminent collapse at various points in the tunnel. As a result of these studies, Park Service maintenance crews completed immediate emergency repairs to support the roof in Gallery 3, block off the outer portion of Gallery 2, and place additional timber rings to reinforce the 12" x 12" timber lining between Galleries 1 and 2 and below Gallery 6.²¹

Detailed field studies of the tunnel and galleries led to designs and estimates for permanent repairs by May 1932. Designs included a 6" thick mat of gunite for the ceiling of Gallery 1, with 1" round steel bars grouted eight feet into the ceiling with hooks to support the gunite mat, itself reinforced with 1/2" latticed steel bars. A reinforced concrete wall would replace the disintegrating rock of the east wall of Gallery 1, and the seams and cracks in the cliff face above the proposed wall would be filled with gunite to a height of 20'. The concrete lining in Gallery 2 was to be tied to the existing lining and extend beyond the outside line of the masonry wall along the edge of the cliff face. The BPR awarded the contract for these repairs and additional work on the road immediately below the west portal to the Reynolds-Ely Construction Company of Springville, Utah, on 20 July 1932, for the low bid of \$112,737.85.²²

The contractor worked from 28 July 1932, through 13 April 1933, completing the project as planned and amended. The major work involved tunnel enlargement to accommodate new concrete and timber lining thereby retaining the 16' x 22' tunnel clearance. In sum, the contractor erected 164 linear feet of 12" x 12" timber and 726 linear feet of concrete lining, which had the effect of repairing 1,012' of tunnel. The exact lining accomplished is as follows:²³

²¹ Davis, "Final Construction Report Supplemental," 3-4; F. A. Kittredge, Chief Engineer, to the Director, letter, 21 June 1931, Zion Codex, ZNP Library.

²² Davis, "Final Construction Report Supplemental," 4-7.

²³ Ibid., 7-8.

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Linear Feet	Station to Station		Description
48	46+55	- 47+03	Timber replacing 8' x 8' timber
92	55+54	- 56+46	Timber lining w/ gunite between and behind plumb post, instead of timber lagging.
24	73+94	- 74+18	Timber lining replacing timber lining placed by NPS which was damaged when a block of rock fell from the ceiling.
136	48+80	- 50+16	Continuous concrete lining, including Gallery 3.
24	50+50	- 50+83	Concrete lining in four 6' sections with 3' spaces.
207	50+46	- 59+90	Concrete lining, 22 6' and 25 3' ribs w/ 3' spaces
10	65+28	- 65+43	Concrete lining, 2 5' sections w/ a 5' timber space between in solid timber ring section.
241	68+30	- 69+04)	Concrete lining continuous.
	72+27	- 75+94)	
108	66+44	- 67+32)	Concrete lining, 36 3' ribs
	74+18	- 74+54)	in alternate bays of 12" x 12"
	74+80.5-	75+16.5)	timber lining.
	75+60.5-	76+76.5)	

During the process of blasting to enlarge the tunnel on 27 September 1932, a large sandstone block fell from the roof between Stations 72+60 and 73+90. The triangular-shaped block measured 8'-15' in width and extended 18' above the tunnel ceiling before it collapsed and brought 555 cubic yards of debris crashing down to the roadway. Thirty-eight men worked three days to reopen one lane of traffic, and another four days to clear all of the rubble. In February 1933, the contractor removed and replaced 137 linear feet of concrete paving, 6" deep by 20' wide, to repair the roadway damaged by the cave in. Other than this incident, and aggravating traffic delays while the work progressed, few problems arose during this supplemental project.²⁴

Reynolds-Ely subcontracted the gunite work to the Case Construction Company of Los Angeles. Sand for the concrete was obtained from a pit along Highway 89, a short distance south of Mount Carmel Junction, rather than the long-used pit at Rockville, which would have presented traffic and steep uphill hauling problems. The subcontractor first gunited the cliff face

²⁴ Ibid., 12-13, 22-23.

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at the east side of Gallery 1 to a height of 20' above the concrete wall. He then moved equipment to the east portal and proceeded quickly to Gallery 3. Crews gunited the east portal to a height of 8' above the top of the portal, and then shot a new layer of gunite over the cracks and seams in the ceiling of Gallery 4 for study purposes. The subcontractor returned in October 1933, and placed the 6" gunite mat on the ceiling of Gallery 1 in 1-1/2" layers, then gunited all concrete and rock surfaces in the gallery.²⁵

Additional work at Gallery 1 included the removal of disintegrated rock extending from the east side of the gallery up the tunnel about 74', and replacement of the rock with a reinforced concrete wall. This work is clearly visible today from the pioneer trail, and although aesthetically displeasing, it was necessary to maintain the integrity of the tunnel at this point. The wall was completed in six sections, each section tied to the native rock with reinforcing steel bars grouted into the bedrock. Excavation and concrete lining were also performed at Galleries 2 and 3 to shore up weak and moving bedrock.²⁶

Crews began the extensive concrete lining detailed previously immediately after they enlarged the tunnel for this purpose. They poured 6' sections or ribs, leaving three-foot spaces between sections from Station 57+05 to 59+00. Men poured the concrete by hand shovel within forms of 1" and 3" timber from a scaffold at spring line. The subcontractor later applied gunite to the rough concrete surface.²⁷

Additional minor work performed during the 1932-1933 supplemental construction project included rebuilding the masonry guardrails in Galleries 1, 2, and 3 (which had been dismantled during lining operations); replacing curbing that had been damaged or dismantled during lining operations; replacing the damaged concrete roadbed previously mentioned; and application of an autumn brown stain to the walls and gunited seams of Gallery 1 as an aesthetic measure. The contractor completed all work April 12, 1933, using a total of 241 calendar days, at a total construction cost of \$152,908.62. Although satisfied with the project, BPR Junior Highway Engineer F. LeRoy Davis, who supervised the work along with R. A. Brown, recommended that periodic inspections be made since varied sections of the tunnel-

²⁵ Ibid., 13-15.

²⁶ Ibid., 15-16, 19-20.

²⁷ Ibid., 17-19.

--especially the old timber-lined sections--continued to show signs of movement and potential failure.²⁸

The last major construction project within the tunnel was the "tunnel lining project" awarded to Reynolds-Ely Construction Company of Springville, Utah in late 1936 for the bid price of \$226,423.95. The contractor moved onto the job in October and completed work June 8, 1937.²⁹ Although the author found no further information on this project, he believes that it entailed the lining of the remainder of the tunnel since the entire tunnel is today lined and no data was found concerning a subsequent similar project. The high cost of the 1936-37 project also suggests that all tunnel sections not already lined were completed at this time.

Problems and Repairs Since 1937

Construction and major alterations to the tunnel were completed with the 1936-37 lining project, but repairs and minor modifications have been ongoing concerns of the Park Service and Bureau of Public Roads (today's Federal Highway Administration). The enormous amount of blasting within the Navajo cliff face--coupled with normal actions of snow, ice, thaw, freezing temperatures, earthquakes, and natural erosion--basically ensures that cracking, movement, and landslides will occur over the years. The first major slide happened soon after tunnel completion in 1934 when a massive portion of the cliff above Gallery 6 sloughed along vertical fault lines and sent tons of sandstone crashing to the talus slope below. Another slide containing an estimated 2,850 cubic yards of material left a fresh sandstone wound 70' high, 50' wide, and 18' deep just west of Gallery 3 on 2 January 1942. Neither of these slides caused damage to the galleries or tunnel, but reminded park administrators that nature would continue to excavate the cliff face and perhaps someday expose the tunnel within.³⁰

Slides of 9 October 1949 and in spring 1950 damaged the reinforced concrete arches of Galleries 4 and 5, but the worst

²⁸ Ibid., 21-30, attached financial statement.

²⁹ ZNP Superintendent's Annual Report, 1937, history boxes, ZNP archives.

³⁰ Dave D. Hendricks, Assistant Engineer, to Superintendent Franke, memorandum, 14 January 1942, Landslides: Road Damage and Repair File, history boxes, ZNP Archives.

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landslide to date occurred following two months of heavy rains on 28 April 1958. At 6:35 a.m., a huge column of rock sloughed off the cliff face above Gallery 3 and sent thousands of cubic yards (estimated 80,000 tons) of material down to Pine Creek Canyon. Along the way it demolished the gallery, backfilled the tunnel, and almost completely closed the main bore. Damage included the gallery--which was a total loss aside from the remaining hole in the cliff--and a large section of roadway along with 45' of lining within the tunnel. Working feverishly, repair crews managed to open one lane of traffic by 3 May, and to clear the remaining concrete, steel, and rock debris by 16 May when two-lane traffic resumed, but the slide's effects persisted. Permanent repairs did not begin until October 1959, and continued to February of the following year, during which time men sealed the gallery with a wall of concrete which allowed light into the tunnel through two screened windows at spring line. They also applied concrete to about 60'-70' of the north tunnel wall immediately downgrade of the windows--which was now dangerously close to the exterior cliff face--and secured it with a series of 8' bolts grouted into the remaining natural rock. The men also repaired the lining and concrete surface that had been damaged, closing the tunnel (which also meant closing the Zion-Mount Carmel Highway) to all traffic 5-15 October 1959, and to large vehicles 19-20 January 1960, to complete the repairs.³¹

During repairs in late 1959, the Bureau of Public Roads and Bureau of Reclamation placed temporary "strain gauges" at several tunnel galleries to monitor cliff movements and recommended the placement of permanent measuring devices. Later, these permanent devices were installed and connected to monitoring equipment at park headquarters. In May 1961, a complete report for the previous year submitted to the BPR indicated that readings were within limits and that the tunnel had not been subjected to abnormal stress. Others since that date have questioned whether the devices really work, and in any event, landslides and rock falls are about as predictable as earthquakes and likely to occur without recent movement being detected.³²

³¹ ZNP Superintendent's Monthly Narratives, February, 1951; March and April, 1958; September, October, November, 1959; January and February, 1960, history boxes, ZNP archives. See also Garate, "The Zion Tunnel," 51-52.

³² ZNP Superintendent's Monthly Narrative, May, 1961, history boxes, ZNP archives; Dave Karaszewski, Zion National Park Chief of Maintenance, taped interview with Michael F. Anderson, 8 July 1993.

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Decidedly, the late 1950s were not particularly good years for park administrators responsible for the Zion-Mount Carmel Highway Tunnel. The rockslide at Gallery 3 was followed by an accident, suicide, or murder at Gallery 4, in which Mrs. Milo Long fell from the window to canyon rocks 200' below. Park workers had to run a cable down to the rugged canyon bottom and winch the body back up through the gallery. This incident, perhaps along with others' propensity for leaning out the windows, prompted park crews to raise the masonry guard walls at each of the remaining galleries to 42" in November (Gallery 1) and December 1959. Other safety measures suggested for the tunnel in this year included painting the curbing white in alternate 10' sections, which was done in June 1960 and again in 1963, and putting up guardrails within the tunnel, which apparently was not done. Since the 1960s, crews have blocked vehicle access to the galleries with a 9" high curb, painted the lower portions of the tunnel's walls white for hundreds of feet from each portal, installed reflectors on walls and along the centerline, and continued to paint portions of the curbs--all in the interests of safety. These measures coupled with traffic control have mitigated but not eliminated accidents within the tunnel.³³

The occasional fall of rocks and humans presented the more spectacular incidents of tunnel difficulties in the early years, while larger problems loomed on the horizon. When the Bureau of Public Roads completed the tunnel and highway in 1930, traffic was light and vehicles narrow. A 20' roadway, 4' wider than standards of the time, seemed more than adequate. By the 1950s, tourist numbers and local users had multiplied beyond the planners' imaginations, however, and vehicles had assumed new dimensions. Construction of Glen Canyon Dam brought the situation to a head in the latter part of the decade with long

³³ ZNP Superintendent's Monthly Narratives, August and September, 1958; November and December, 1959; June, 1960; February, 1963, history boxes, ZNP archives; Wesley Dennett, Springdale, Utah, taped interview with Michael F. Anderson, 8 July 1993.

In an interview with the author, Wesley Dennett, native of Springdale and long-time employee at Zion NP, related the story of the unfortunate Mrs. Long. Mr. Dennett, who was one of three men assigned to recover the body at the base of the gallery, insists that the story at the time was that she was murdered by her husband.

Curbs which now block the galleries to keep motorists from pulling off have the desired effect for the most part, however, some motorists today just stop in the road way and wander over to the gallery to admire the vistas.

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lines of heavy equipment moving through the tunnel to reach the construction site in the eastern part of the state. Rangers had to escort these vehicles through the tunnel in convoys in 1958 and 1959 and by the latter year, park administrators had had enough of it. In 1959, they implemented regulations banning commercial vehicles from the Zion-Mount Carmel Highway from 1 June through 30 September of each year, and placed signs to this effect at Mt. Carmel Junction and the town of LaVerkin. Local commercial interests as well as the state road commission took a dim view of the ban, but Superintendent Frank R. Oberhansley stood firm and defended the action at a January 1960, road conference in Salt Lake City. The ban held, and completion of the highway from Hurricane to Fredonia in these years (Utah Highway 59 and Arizona Highway 389, built primarily as a commercial bypass) eased some of the local opposition.³⁴

Problems with the tunnel since the 1960s have not involved landslides or structural failures, but rather, the continuing increase in traffic through the tunnel and the advent of more and larger tour buses and recreational vehicles. Accidents through the years have ranged from heart attacks to head-on collisions, and occurred with increasing frequency until a Federal Highway Administration study instigated improved signing, vehicle convoys during the winter months, and one way traffic control for the remainder of the year. Today, rangers at each portal communicate with 2-way radios during daylight hours and control the passage of vehicles, ensuring that two of the behemoth recreational homes on wheels do not approach each other from opposite ends. Operators of such vehicles are banned from using the tunnel at night, but of course, they do in fact use them at night and it is simply a matter of chance whether two will meet coming around one of the tunnel's five curves. The Federal Highway Administration has identified several structural solutions to relieve the traffic problems, ranging in cost from \$17 million to \$33 million and including construction of a parallel tunnel, but for now, traffic control with minor delays handles the dilemma as well as can be expected.³⁵

³⁴ ZNP Superintendent's Monthly Narratives, December, 1958; January, July, August, September, October, December, 1959; January, 1960, history boxes, ZNP archives.

³⁵ United States Department of the Interior, National Park Service, "Zion National Park Statement for Management," bound manuscript, September 1992, copies available at ZNP. The author observed one such lumbering "motor home" approach the east portal at 9:00 p.m. as the HAER team prepared to take photographs within the tunnel. No physical barrier keeps any vehicle from entering

DESCRIPTION

The tunnel today retains its structural integrity as completed in 1937, with more or less minor modifications made since that date for maintenance or safety purposes. At the west portal, the approaching roadway--the last line of the switchbacks--is cut into the cliff face to allow a straight centerline entrance and adequate sight distance into the tunnel. A United States Geological Survey benchmark bearing the date of 1931 and an elevation of 4835' is cemented into the roadway at the north portal base. The asymmetrical masonry facade and symmetrical arch framing the tunnel entrance are of cut stone approximately 2' thick, and appear as laid by Shea and Shea in 1929. Masonry lining extends into the first 20' of tunnel, at which point the tunnel walls and ceiling change to a continuous concrete lining to approximately 10' upgrade of Gallery 6. Construction crews sealed off Gallery 6 with concrete soon after construction due to water seepage, but its location is easily detected by an indentation in the wall, 5' deep at the downgrade and 2' at the upgrade. The walls of the tunnel from the west portal to Gallery 6 are painted white (some time after 1960), at first to a height of approximately 6' then reduced to a height of 4'. At this point the tunnel curves slightly to the next tangent, as it does at every gallery to maintain as consistent a distance from the exterior cliff as is possible.³⁶

Ten feet beyond Gallery 6, the tunnel lining becomes intermittent concrete ribs 3' wide and approximately 1' deep with 3' spacing. With few exceptions where ribbing is 5'-6' wide, intermittent concrete lining throughout the tunnel is of 3' ribs poured up

the tunnel once the rangers go off duty.

³⁶ The following tunnel description is based primarily on field observations conducted over a period of nine hours the night of July 21-22, 1993. The author was in the company of Brian Grogan, photographer for the project taking large format photographs of the tunnel interior, project leader Todd Croteau, and project architects Laura Culberson and Christopher Payne. I am indebted especially to Laura and Todd for acquiring a knowledge of the tunnel's engineering and architectural features as well as its history and pointing out facets of the construction I might have missed.

Certain descriptions are also based on the author's field investigations of June 14, 1993 along the pioneer trail beneath the tunnel cliffs with Laura Culberson and Todd Croteau, and of July 4, 1993, at the east and west tunnel approaches.

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against the native sandstone. The intermittent concrete lining continues upgrade to approximately 75' from Gallery 1, where it transitions to full concrete lining to the gallery and for another 75 feet or so upgrade. Gallery 1 is the "large window," at one time offering motorists a pulloff and grand view of Pine Creek Canyon backed by the East Temple. The masonry guardwall--originally 36" high and raised to 42" in the late 1950s--is offset from the sandstone cliff face approximately 3'. A concrete sidewalk 2-1/2' to 3' wide is at the base of the wall and a concrete tread extends from this point to the roadway, punctuated by the 9" high, 7" wide curb which prevents (almost all) motorists from pulling off today. A drainage hole at the downgrade side of the gallery is cut under the sidewalk, allowing runoff to the cliff face outside. This description of the guardrail, sidewalk, tread, curb and drainage at Gallery 1 applies to the construction at Galleries 2, 4, and 5 as well (except for size).

The exterior of Gallery 1, intimately viewed from remnants of the pioneer trail below the cliffs or from a longer range at the highway's Nevada Switchback pulloff, is somewhat marred from cliff slides on either side and the extensive concrete work necessitated by the slides and the cliff's instability at this point. Concrete and gunite emanating from the window were purposely stained to blend with the natural sandstone from a great distance, with minimal success, but the huge concrete wall viewed immediately east is untreated and an eyesore. Crews built this wall in 1932-33, soon after tunnel construction and the occurrence of the first cliff slides, to support the fragile cliff wall at this point.

The terrain beneath Gallery 1 has returned to a semi-vegetated condition, although it is now a talus slope rather than the nearly sheer cliff it once was. During tunnel construction, truck loads of fine blasted sandstone as well as bits of metal and concrete debris were dumped out the window forming this slope, but grasses, shrubs, small oak, and boxelder have since covered most of the "muck." The view from the switchbacks up toward the gallery is enhanced by the recessed, north-facing microecosystem, which supports fir, ponderosa, and deciduous trees normally found a thousand feet higher at this latitude.

At Gallery 1, the tunnel bore veers slightly to the next tangent and the contractor's "signature" is noted in the roadway on the right (south) a few feet from the curb. It is etched in the concrete tread, reads "Nevada Contracting Company Dec 8, 1929 Station 67+50[.]5", and is surrounded by an etched rectangle. Just ten feet beyond the signature, the tunnel's continuous concrete lining switches to a 75' segment of the original timber

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lining, reinforced later with 3' concrete ribs poured intermittently between the vertical timbers. This timber lining--which was installed from the first when builders realized permanent reinforcement would be needed--is repeated in a few other sections up the tunnel, and is of 12" x 12" vertical timbers on each wall continuing across the ceiling. Horizontal wall plate timbers at spring line provide additional support for the ceiling members. The timbers are backed by tightly-fitted, horizontal, 4" x 12" lagging boards which also run the full height of the walls and across the ceiling, forming a continuous wooden arch. At varied points within the tunnel, original timber lining was covered by continuous concrete and/or gunite by 1937, but at this and several other points upgrade the timbers and board backing appear purposely exposed and preserved as examples of the original lining.

From the end of this timbered section, the lining is continuous concrete for approximately 120', then another section of timbered lining (exactly like the first) approximately 200' long extends to within 50' of Gallery 2, where the lining is again continuous concrete flanking the gallery. Gallery 2 is a much smaller version of Gallery 1, approximately 25' wide, except this gallery's walls and ceiling are entirely concrete sprayed with gunite. The view from the window is basically north overlooking the Nevada Switchback and the downslope roadway running west toward the mouth of Pine Creek. Vegetation on the talus slope below has recovered as at Gallery 1 with thick trees and grasses covering construction muck, bits of rail and piping, and debris tossed from the window over the past 63 years.

Continuous concrete lining runs upgrade of Gallery 2 for about 100' then changes to intermittent concrete lining to approximately Station 50+50, where it again turns to continuous concrete for 100' before Gallery 3 is reached. The above-mentioned intermittent lining is a mix: most often the standard 3' ribs with 3' spacing of gunited natural rock wall, but in spots, 5'-6' concrete ribs and 3' spacing of horizontal boards. The continuous concrete walls flanking Gallery 3 have measurements and building instructions painted on the bare concrete--vestiges of reconstruction required by the 1958 cliff slide which backfilled the tunnel at this point. Concrete circles hide the 8' bolts used to tie the lining to the fractured cliff face for about 60'-70' along the north wall just downgrade of the gallery. There are five bolts in a column running up the wall to just above spring line, with columns spaced 5' apart, for a total of 50-60 bolts. No attempt was made to hide these signs of reconstruction (completed in 1960) with the usual gunite veneer.

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Gallery 3 as originally constructed exists only in historical photographs and narrative, as the 1958 cliff slide demolished its built features as well as scaled the cliff face perilously close to the tunnel within. Crews repairing the window in 1959-1960 did not reconstruct the gallery, but rather built a concrete wall across the opening. Access to the outside is through a padlocked double door in the concrete wall. Two large windows above the door, each screened with 6" wire mesh, allow light to penetrate to the tunnel. Outside the wall, a narrow ledge the depth of the remaining cliff face remains with no sign of the original guard wall. A large propane tank rests on this ledge on the upgrade side. Galleries 3, 4, and 5 cannot be seen from the roadway to the west and are not easily accessed from Pine Creek, thus, exterior aesthetic features are not considered.

The tunnel between Galleries 3 and 4 is lined with intermittent concrete ribs and the entire section is coated with gunite, except the sections immediately adjacent to both galleries which are continuous concrete coated in gunite. The continuous lining extends 25' in both directions from Gallery 4. This gallery is similar to Gallery 2, except that it is slightly wider and the curb blocking the pulloff has a drainage hole which allows tunnel runoff to seek the drainage hole beneath the sidewalk leading to the outside. The view from the gallery is restricted by the massive sandstone wall immediately across Pine Creek, which at this point is extremely narrow.

The lining between Galleries 4 and 5 is the same intermittent concrete as noted above, with continuous concrete lining 10' downgrade of the gallery and 35' upgrade. Gallery 5 is the narrowest of the cliff windows, measuring only 12'-15' wide, but is otherwise constructed virtually the same as Galleries 2 and 4. The view from the window is even more restrictive than Gallery 4, with only the solid sandstone wall immediately across Pine Creek and the narrow creek gorge itself visible. Here, as at Gallery 4, cracks in the gunite are traced in blue paint to record movement at these points. These cracks have progressed beyond the paint, indicating that the earth continues to move within the tunnel.

The white paint coating the lower 4' of the tunnel wall begins again about 35 feet downgrade of Gallery 5 and continues out to the east portal along with the standard intermittent concrete rib lining. The east portal has no masonry facade, but is coated with the stained gunite applied in 1932-33. It opens immediately upon the Pine Creek gorge, which is spanned by the upper Pine Creek Bridge (HAER No. UT-39-J).

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The wearing course throughout the 5,613' tunnel is the original 20' wide, 6" deep poured concrete, except the 137-foot segment at Gallery 3 which was replaced to the same width and depth following the 1958 cliff slide. A continuous double yellow center line extends the length of the tunnel, with reflectors spaced 20' apart affixed to both lines. Metal insets, some with sunken reflectors, run along the middle of these lines indicating an earlier reflection system, but it is unknown if these date to original construction. Continuous curbs approximately 9" high extend one foot out from the base of the tunnel walls and are original, although segments of these were replaced during the 1932-33 supplemental construction and no doubt other segments were replaced following the final lining project of 1937. The curbing along the north tunnel wall was extended across the galleries some time after 1960 to prevent drivers from using the pull-offs. The "strain gauge" monitoring system installed circa 1959-60 consists of a 4" metal conduit pipe running atop the south curb from the west portal to Gallery 3, with 1" metal conduits branching under the road surface or over the ceiling to each of the first three galleries, thence to sensors flanking the galleries on the north tunnel wall. The tunnel retains its original 16' x 22' main bore dimensions, but this is a result of additional boring in 1932-33 and again in 1937 to accommodate the added tunnel lining.

SIGNIFICANCE/CONCLUSIONS

Although the tunnel retains its structural integrity dating to 1937, it has lost much of its aesthetic integrity due principally to nature's dictates, required repairs, and increased traffic since World War II. The Bureau of Public Roads and National Park Service designed the tunnel to be virtually invisible from the roadway below, but today's motorist ascending the switchbacks may note the concrete extending from Galleries 1 and 2, the concrete wall beside Gallery 1, and fresh slide scars along the cliff face. The concrete, of course, was required for structural stability and could not be foreseen nor circumvented. Cliff scars left by periodic slides also could not be predicted nor prevented and are natural, especially along the vertically-jointed Navajo Sandstone. Still, they are aesthetically displeasing and were almost certainly accelerated along this particular cliff face by the 150 tons of dynamite detonated during tunnel construction. These detractions from the exterior landscape are noted only by those stopping at the pull-offs along the eastern switchbacks, since the sane motorist spends little time gawking at the scenery while ascending this sinuous roadway.

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More serious perhaps is the loss of an uninterrupted drive into the tunnel, punctuated perhaps by a stop at one or more of the galleries to admire the vistas unseen and unseeable prior to the tunnel's construction. The National Park Service built the tunnel with galleries to allow these views and designed the roadway to flow safely and smoothly into the tunnel and out the other end. Today, however, rangers must hold up traffic at each portal during most daylight hours to control the number and size of modern vehicles. Too, the once unseen vistas are again unseeable as motorists must proceed nonstop through the tunnel.

Despite minor structural changes and major detractions to aesthetic integrity, the Zion-Mount Carmel Tunnel remains a marvel of imagination, engineering, and construction. The choice to bore through the cliff face rather than construct a half tunnel on the exterior (though the latter was considered) is an excellent example of the early NPS philosophy of marring the natural landscape as little as possible with built structures. Locating the tunnel along five tangents within a space of more than a mile without access to either portal nor to the above terrain certainly taxed the mathematical acumen of BPR surveyors and engineers. Building techniques such as boring an exterior stope to reach roadway grade (at Gallery 4), building a tunnel from the inside out through the opening of galleries, and ring drilling to achieve the tunnel's main dimensions had been used in mining operations prior to this date, but were likely used for the first time to construct a vehicular tunnel on this project. Add to these facets of engineering and construction the final result--the longest vehicular tunnel in the National Park System and the longest in the western United States at the date of its construction--and the historical significance of the Zion-Mount Carmel Tunnel is certainly established.

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ZNP Superintendents' Monthly Narratives, February 1951; March,
April, August, September, December, 1958; January, July,
August, September, October, November, December, 1959;
January, June, February 1960; May 1961; February 1963.

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Zion National Park Roads and Bridges

Zion-Mount Carmel Highway, 2 miles east of Zion Canyon Scenic Drive

Springdale Vicinity

Washington County

Utah

HAER NO. UT-39-A

HAER

UTAH

27-SPDA.V,

3A-

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HISTORIC AMERICAN ENGINEERING RECORD

National Park Service

Department of the Interior

P.O. Box 37127

Washington, D.C. 20013-7127

ADDENDUM TO:
ZION-MOUNT CARMEL HIGHWAY, TUNNEL
Zion National Park
Two miles east of Zion Canyon Scenic Drive
Springdale vicinity
Washington County
Utah

HAER UT-39-A
UTAH, 27-SPDA. V, 3A-

PHOTOGRAPHS

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National Park Service
U.S. Department of the Interior
1849 C Street NW
Washington, DC 20240-0001